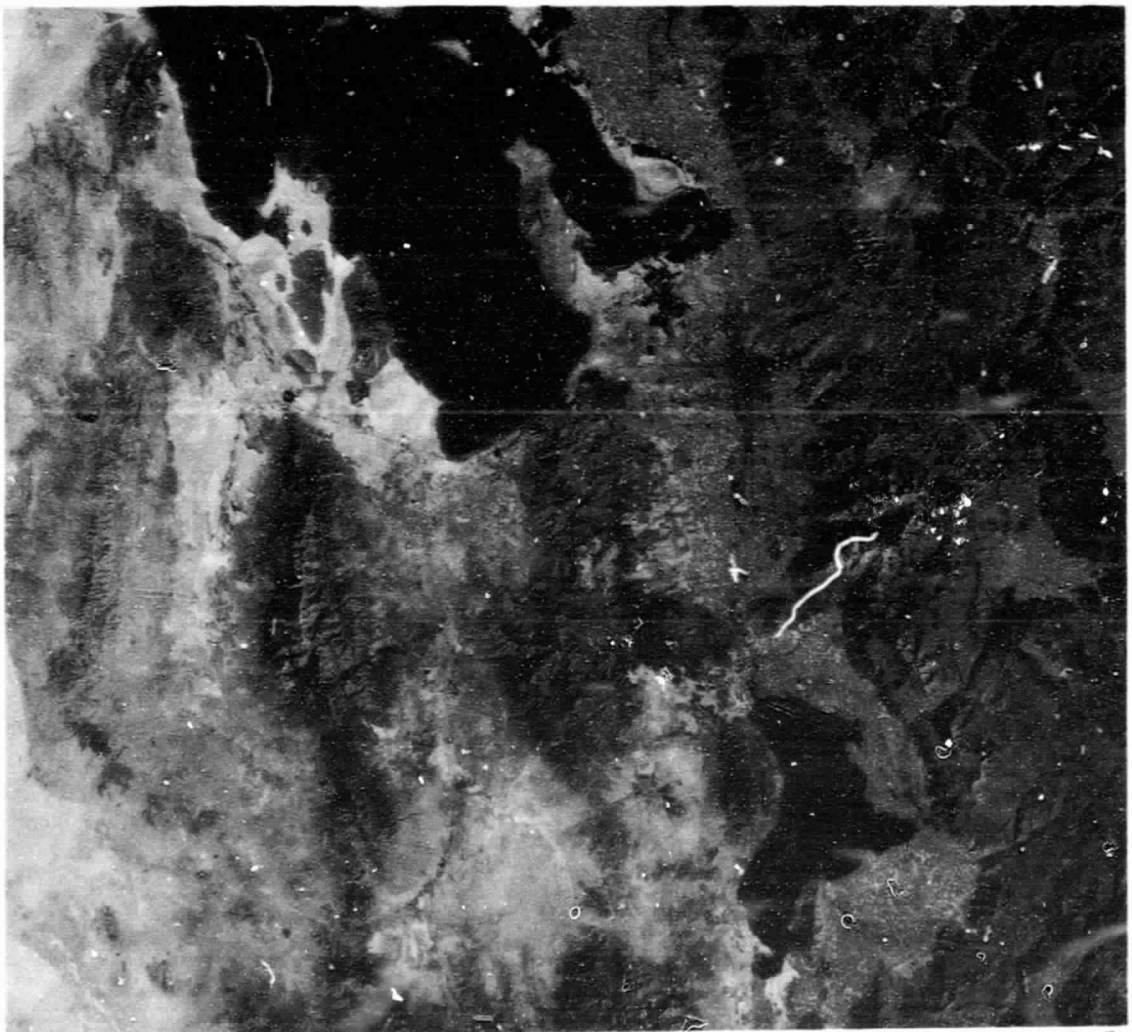

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ANNUAL REPORT

NASA Grant #NAGW-95

IDENTIFYING ENVIRONMENTAL FEATURES FOR LAND MANAGEMENT DECISIONS

October 27, 1981

Prepared for the

National Aeronautics and Space Administration

by the

Center for Remote Sensing and Cartography
Applied Technology Division
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INTRODUCTION

The comments made in the first four pages of the Semi-Annual Report dated May 8, 1981 reflect the attitudes, facilities, and organizational status of the Center for Remote Sensing and Cartography (CRSC) at the present time. CRSC feels at home at the University of Utah Research Institute (UURI), with the majority of administrative adjustments having been made this past year. The staff at CRSC is able to devote an increasing amount of time to refining the technical skills necessary to maximize our ability to respond to the information needs of natural resource decision makers. The section below briefly discusses the areas in which technical development is taking place.

TECHNICAL DEVELOPMENTS

CRSC is working to establish and maintain a high level of technical competence in the following four areas: Landsat digital processing; aerial photograph interpretation; geographic information systems; and cartographic methods. Developing strength in these four areas will allow CRSC to have its greatest flexibility in responding to the needs of its clients.

Landsat Digital Processing.

In the past few months, we have realized substantial advantages through our access to UURI technical facilities. Specifically, we now have operational Landsat digital processing capabilities with the ELAS software package which has been set up on the Earth Science Laboratory's PRIME computer at UURI. Consequently, we have the convenience of doing almost all of such work in our own lab, and have access to professional computer specialists as we get acquainted with and work out the bugs in using ELAS at our facility. Although we now use ELAS exclusively for our processing of multi-spectral scanner data, including the many statistical

routines for classification and mapping, a good deal more effort will be necessary to become fully operational with digital terrain data and geographic information system aspects of ELAS. This is a high priority for us.

CRSC has had a number of projects involving digital processing of Landsat which have provided valuable learning experiences; such experience has been necessary to help us acquire a feel for when Landsat digital analysis will be a cost-effective approach to obtaining needed information. We feel much more confident in our abilities to generate alternate remote sensing study approaches and in selecting the best approach for a given situation. By asking a series of questions, and comparing the responses to our experience base (which includes vicarious experiences through others in the literature), we are provided with a means of selecting a study approach which will produce the desired final product. The primary questions are:

Objective	- What is to be studied and mapped?
Purpose	- Why is it to be mapped, how and by whom will the map be used?
Resources	- What maps, aerial photography, and imagery are available?
Study Area	- What is the size, topography, and nature, in terms of contrasts between surficial features, of the study area?
Standards	- What are the mapping accuracy standards, in terms of scale, legend categories, size of minimum mapping units, etc?
Limits	- What are the practical limits to the project in terms of time, budget, and personnel?

Thus, as we develop a proposal or a study plan, we are careful to avoid using an inappropriate remote sensing medium. Of course, uncertainty accompanies any research effort and we will continue to employ new techniques

where a reasonable likelihood of success is apparent. We have enough in-house science skill relative to environmental analysis that we are able to interact on a problem/research design level with the agency or client.

Aerial Photograph Interpretation.

The second technical area we are anxious to continue developing is aerial photograph interpretation. The ability to efficiently produce maps from the reservoir of aerial photographs currently available is often the only means of satisfying a resource manager's information needs; the level of ground detail needed often exceeds the capabilities of the present Landsat satellites. Fortunately, various NASA flights, the National High Altitude Program of NCIC, and other sources of aerial photography have created a tremendous wealth of photographic remote sensing material.

We have been vigorously acquiring the latest aerial photograph indexes and establishing the contacts necessary to expedite acquisition of photography. We have purchased our own mirror stereoscope and a few other materials to augment our interpretive abilities. We have recently located a company in Salt Lake City which can produce direct prints and photo enlargements from film positives; we are confident this will prove to be a valuable asset.

This emphasis on photo interpretation will facilitate the traditional use of photos as an intermediate "platform" in Landsat digital analysis, as well as the expanding primary use of air photos for meeting project needs. We are also working to better organize the laboratory facility at CRSC to provide a well-indexed library of literature, Landsat images, photos, maps, and computer tapes.

Geographic Information Systems.

Now that substantial progress has been made in using ELAS for digital processing, we plan to devote more attention toward developing a geographic information system (GIS) capability on the PRIME computer. We have had experience with GIS applications in previous projects and are convinced of the need to have operational GIS routines fully applied to practical resource management problems. Since the scientists in the Earth Science Laboratory (ESL) at UURI have similar interests and needs, we will coordinate GIS development with them. Although ESL has several digitizing tablets available at the present time, we plan to interface CRSC's digitizing tablet with the PRIME and the GIS software ESL is developing. Of course, utilizing the capabilities of ELAS to integrate multi-spectral digital data with terrain and other environmental information is a primary goal at CRSC.

Cartographic Methods.

We have recently been able to make use of a new Kargl cartographic projector in the University of Utah Geography Department; use of the Kargl has expedited work on several projects. Access to equipment such as a zoom transfer scope and photographic and darkroom facilities in the Geography Department allows us to perform essential cartographic tasks until we can afford such facilities here. We are mindful that the best remote sensing study is worthless unless accurate maps are produced to convey the information obtained.

CRSC OUTREACH

Over the past few months, our attention has been directed primarily at performing project work and developing technical capabilities. However, several visitors have toured the lab and given us an opportunity to promote

remote sensing as a management tool.

The manager at CRSC has been invited to instruct a course entitled "Range Inventory and Analysis" at Brigham Young University. Heretofore, such course has focused exclusively on field methods for acquiring range resource information. The course now includes several weeks which are devoted to the use of remote sensing media to augment resource management decision-making. We think that providing "hands-on" remote sensing opportunities to aspiring resource managers is an essential aspect of the educational process. Of course, the NASA commitment to the course goes little beyond providing the means (i.e., CRSC) to provide such hands-on experience. An additional bonus from this activity is the professional enhancement of CRSC's manager in the area of non-remote sensing; we hope to develop our abilities to correlate quantitative data with our remote sensing analysis to better evaluate and describe environmental features.

The director of CRSC was invited to present professional papers at three international symposia, expenses paid, during the year:

1. Conferencia Internacional, Recursos Naturales y Desarrollo Regional el Caso de las Zonas Semi-Aridas, sponsored by Centro de Investigacion en Quimica Aplicada. Cocoyoc, Morelos, Mexico. 6-8 October 1980.

2. Primer Simposio Colombiano Sobre Sensores Remotos, sponsored by Centro Interamericano de Fotointerpretacion. Bogota, Colombia. 27-31 July. 1981.

3. 16th International Symposium on Remote Sensing of Environment, sponsored by Environmental Research Institute of Michigan. Cairo, Egypt. 3-9 November 1981 (now postponed to 19-25 January 1982).

During the year, CRSC formally introduced its publication series. From August 1980 to August 1981, the following titles were released under the principal authorship of CRSC staff, with some supporting personnel:

CRSC 80-2. Uinta Basin Wetland/Land Use Study: A Merger of Digital Landsat and Aircraft CIR Techniques (M. K. Ridd, J. G. Christensen, L. D. Clark, and K. F. Landgraf). NASA Grant NSG-7226 Project. 27 pp plus 79 pp Appendix.

CRSC 81-1. "Review of MX Vegetation and Land Use Environmental Technical Reports (ETR-14 and ETR-20)," in Review of the Air Force's Draft EIS on Deployment Area Selection and Land Withdrawal/Acquisition for the MX Missile System: A Report to Governor Scott M. Matheson, Utah Consortium for Energy Research and Education. (R. A. Jaynes, M. K. Ridd, and J. A. Merola). pp 221-227.

CRSC 81-2. Digital Landsat Analysis and Inventory of Guayule Distribution and Density in Northern Mexico (M. K. Ridd and J. A. Merola). 20 pp

CRSC 81-3. Satellite Mapping of Shoreline Fluctuations, Farmington Bay, Great Salt Lake, Utah (M. K. Ridd, J. A. Merola, and R. A. Jaynes). NASA NSG-7226 Project. 16 pp

CRSC 81-4. Irrigation Detection by Satellite, Iron County, Utah, 1978, 1979, and 1980 (M. K. Ridd, K. F. Landgraf, and L. D. Clark). NASA Grant NSG-7226 Project. 11 pp

CRSC 81-5. Davis County Foothill Development Study. (M. K. Ridd, R. A. Jaynes, J. M. Olsen, E. E. Carr, B. M. Burton, and a technical team of 13 others). A comprehensive geotechnical/urban planning project supported by Four Corners Regional Commission, NASA Grant NSG-7226, EPA, and other agencies. Vol. 1 (83 pp plus Appendix), Vol. 2 (269 pp), Vol. 3 (196 pp), and Vol. 4 (8 maps).

CRSC personnel also released five other publications during the contract year, and delivered several formal and informal presentations. Dozens of visitors have toured CRSC offices and laboratories for formal and informal presentations, ranging from local organization personnel to the Chief of the Earth Survey Applications Division at Goddard SFC. Eighteen foreign dignarities and technical specialists have visited the CRSC facilities, representing Mauritania, Zaire, Upper Volta, Colombia, India, and including an ambassador from Kenya, and a cabinet minister from Mexico. All of these people came to Salt Lake City expressly to visit CRSC and associated organizations.

Farmington Bay Waterfowl Habitat Study

The objectives of this study are: (1) Analyze and map the distribution of waterfowl habitat in the Farmington Bay Waterfowl Management Area (FBWMA) from U-2 color-infrared photography and Landsat data and imagery; and (2) Produce the waterfowl habitat map at a scale to allow registration of the Great Salt Lake shoreline overlays produced in a previous study. After discussing this study with representatives of the Division of Wildlife Resources and the FBWMA manager, the following main purposes for the study have been identified: (1) Provide a tool to estimate the availability of waterfowl habitat as a function of the level of the Great Salt Lake; (2) Provide information regarding the availability of waterfowl habitat to assist Division administrators to estimate waterfowl productivity and establish hunting programs; and (3) Provide a previously unavailable management data base for evaluating development and management proposals. The manager of the FBWMA regularly is confronted with decisions about where to build dikes, where to manipulate vegetation, how to regulate water levels, how to provide habitat diversity for specific species, etc. The development of the legend for the habitat map was done jointly with Division personnel so as to provide the needed information.

Color infrared photography from August 1979 was used to initially delineate areas based on color and texture. The maps were then field checked and map polygous "calibrated" with ground truth. Adjusting the lines drawn at photo scale to 7.5 minute U.S.G.S. quad scale was accomplished with the Kargl cartographic projector. At the present time, we are labeling the map and making final line adjustments. The technical report will be prepared shortly after the map is complete.

Since processed Landsat digital data were available from the shoreline study, we have evaluated the signatures and print maps in light of the waterfowl habitat areas studied. It was clear from the outset that the mapping needs of this study would preclude use of Landsat as a means of feature delineations, but we were hopeful that digital data could augment the process of labeling map polygous drawn from photos. We have found that highly contrasting and complex vegetation/water patterns create sizeable boundary pixel problems. The result has been a large number of signatures which are only weakly associated with readily perceivable environmental patterns.

We hope to augment the analysis of the FBWMA by ordering selected photos from a NASA-Ames U-2 plane flight in June 1981. Analysis of such photography will permit accurate mapping of dikes and other features which have been introduced to the area since 1979.

Sevier River Wetland/Agriculture Study

We have recently completed final preparation of the maps for a study of wetlands and agricultural land use in the upper Sevier River Basin. The technical report is in draft stage and will be forwarded in a few weeks. The Soil Conservation Service is interested in this study because of strict national policies with regard to the management of natural wetlands. Baseline studies such as ours are essential to provide a framework for determining existing wetlands, and eventually assessing which wetlands are natural and which are man-created. The study also provides an accurate update of basin-wide water-related land use for purposes of farm and ranch resource planning. Although the Division of Water Resources was unable to contribute financially to the project, the study provides that agency with the basic information needed for water resource allocation and water development decisions.

The Sevier River study was valuable in assisting us to refine some remote sensing and cartographic techniques. After a short initial trip to the study area, we were able to do the bulk of color/texture delineations in the lab on available high altitude color infrared photography. We then spent a week in the study area field checking the initial delineations with S.C.S. personnel and jointly developing the map legend. The ground truth dimension of the study was expedited by having a light table, adapted for use in an automobile, upon which we could lay the film positive photographs and the map overlays. After field checking was completed, creation of maps at U.S.G.S. quad scale was facilitated by use of the Kargl projector.

Landsat digital tapes were purchased and analyzed to allow the same sort of merging of digital print maps with photos that proved helpful in the Uinta Basin study. Although initial processing of Landsat data showed promise for augmenting the analysis, a couple of factors led to the decision to not use Landsat as a primary analytical medium. The Sevier River Basin situation is quite different from that in the Uinta Basin study in several respects: (1) the available photography in Sevier is five years more "out-of-date"; (2) wetland and agricultural areas in Sevier are much smaller and more accessible to vehicles. Consequently, the need to field check maps and the ease with which field checking was accomplished caused us to emphasize the "direct sensing" part of the study. We were confronted with a situation where to do digital analysis would have taken as much time and cost as an extra trip to the field. Thus, we learned some lessons about the circumstances under which Landsat digital analysis ceases to be cost effective.

Davis County Foothill Development Study

The municipalities in Davis County have been in possession of the final study and ordinance for several months. In discussing the best follow-up

approach with the staff of the Davis County Planning Commission, we have decided to have an initial presentation before the Davis County Council of Governments (COG). We plan such a presentation in the near future, as soon as a slot in the Davis County COG's monthly meeting can be arranged. The Davis County Planning Commission Director who originally conceived the study has left, causing some loss of momentum for the study. The slow down in the construction market has also lessened the interest in foothill development and associated social issues that existed before the current economic conditions. However, sufficient support and interest remains to allow us to be optomistic about the study; in fact, some planners believe this is an ideal time to promote the new ordinance since "threatened" interest groups are less politically active.

We are confident that the contribution of the Davis County Study will be significant as a result of interest shown by other groups. For example, the Utah State Science Advisory Council invited the director and manager of CRSC to present the study to them in a meeting on June 2, 1981. A number of the council members had keen interest in the study since it represents a new "model" of sensitive area study and development which may be applied anywhere. Park City has retained a private planning firm to prepare a city master plan which contains recommendations for hillside development regulation. CRSC was approacned to provide input to the matter and the planning firm and several city planning commission members have since embraced the concept.

Bear River Range Aspen Habitat

This study, mentioned on Page 8 of the Follow-on Proposal for this year, is complete in terms of map production and in the draft stage of technical report preparation. Two primary signatures have been found to

be associated with aspen forests in northern Utah. The technical report represents an effort to correlate detailed field data with spectral signatures. It appears that the available field data will reveal meaningful information about why the Landsat signatures are different.

NASA-Ames Cooperative Demonstration Project

We have recently completed a request by personnel from the Division of State Lands and Forestry to assist in the verification of Landsat digital maps of forest and range resources on the LaSal Mountains. We photographically enlarged pixel sampling units (PSU's) to allow an overlay onto U-2 color infrared film at CRSC. The photos and overlays were sent to the Moab District office where agency personnel were able to make their evaluation. NASA-Ames had previously sent PSU's scaled to match low altitude natural color photos on hand at the Moab office, but, because of significant topographic displacement problems and inappropriate selection of PSU scale, verification was impracticable.

The personnel at Moab have reported that their evaluations showed that the NASA-Ames Landsat classifications were generally over 85% accurate for forest cover, but were typically less than 25% accurate for range types. Although NASA-Ames will likely adjust its classification parameters to improve the maps, the personnel at Moab have concluded that the Landsat medium will probably not be superior to an aerial photo interpretation approach to land cover analysis. The LaSal Mountain area consists of approximately 50/50 forest/range vegetation types, and management standards for classification accuracy and delineation precision suggest a photo interpretation approach.

The purpose of the LaSal Mountain project was to demonstrate the feasibility of state-wide application of Landsat as the primary resource

inventory medium for state-owned lands. However, since the state owns primarily small blocks of land which generally have fairly recent CIR photo coverage, it appears that the cost-effectiveness criterion for medium selection would point to primary use of photos.

A similar demonstration project was initiated some time ago in the Book Cliffs area: the largest block of state-owned land. CRSC has considered limited involvement with the Winter Ridge study area, and has proposed effort to link range treatments with Landsat signatures. However, since there are serious problems with obtaining accurate management histories for the limited field data acquired and since the likelihood for direct management action is moderate, we have decided to concentrate our efforts on projects which are of greater interest to agency managers, and which have a higher likelihood of management pay-off.

Wasatch-Cache Riparian Habitat Study

We are presently underway with this project, mentioned on Page 11 of the 1981-82 follow-on proposal. The project, which is outlined in the study plan (Exhibit A), has presented challenges for aerial photo interpretation and digital processing aspects of the study; a number of the riparian zones are quite narrow and may only be detected with accuracy from photos, whereas Landsat shows promise for detecting high mountain wet meadow areas.

Irrigated Acreage in the Bear River Basin

A contract has been negotiated with the Bear River Commission to inventory irrigated lands as of 1976 in all three states represented in the basin. The study plan for the project, which is well underway, is attached (Exhibit B). This project is an ideal use of Landsat imagery

to accomplish a critical information need. Significant challenges emerge in the study, i.e., the visual and digital distinction of irrigated land from riparian bottomland on the floodplains. The inventory, if successful, will serve as a common reference for future allocations of water in the basin.

Technique Development for Inventorying Aspen and Aspen-Conifer Stands

A contract has been entered into with the Intermountain Forest and Range Experiment Station to use Landsat to detect successional phases of aspen forests (see Exhibit C study plan). The interest of forest managers in the aspen-conifer succession process is keen. As aspen forests are replaced by conifers, the impact to multi-resource uses are dramatic. For example, CRSC has recently been approached to assist in improving assessments of the hydrologic impacts of the succession process by exercising a watershed model written by CRSC's manager. As yet, the infeasibility of conducting large-scale inventories of successional phases of aspen has precluded the acquisition of important management information; the experience CRSC has obtained in digital processing of MSS data for forest areas has encouraged us in the prospect of developing an accurate technique for classifying and inventorying the aspen and aspen-conifer mixed forest types.

Parker Mountain Rangeland Inventory

The attached proposal (Exhibit D) has been recently submitted to the Division of State Lands and Forestry after completing preliminary negotiations about a range resource inventory on Parker Mountain, Utah. Much information on the study areas has already been acquired and the project will proceed to completion as soon as the study plan is finalized.

PRIOR PROJECT FOLLOW-UP

Uinta Basin Wetland/Land Use Study

We continue to receive positive feedback about the uses to which the Uinta Basin study is being put. We have received reports from the S.C.S. that the accuracy of the maps has been very acceptable and have provided that agency with two extra sets of map copies.

Irrigation Detection Study

The efforts to study irrigated acreage in southwestern Utah from Landsat imagery has led the Division of Water Rights to pursue the technique in enforcing state water law. A few months ago, assistance was given to a staff member from the Utah Division of Water Rights in accessing and ordering Landsat scenes for the purpose of prosecuting a particular farmer who is suspected of over-irrigating.

Farmington Bay Shoreline Study

We recently received a letter from Al Regenthal (Exhibit E) which indicates the continuing utility of our efforts to map shoreline changes in the Great Salt Lake. We know that the maps have directly influenced management decisions in the past and we hope that it will have continued use in the future.

Potential Projects

CRSC has recently been approached about providing a wetland and agricultural land-use inventory in the Virgin River Basin. This is a further outgrowth of the projects performed in the Uinta and Sevier River Basins.

We plan to approach several of the state agencies about taking advantage of the huge aerial photo mission completed in the western half of Utah and eastern Nevada by NASA-Ames. It seems that such photography

provides a unique opportunity to perform some widespread and detailed analyses of environmental features never before possible.

CRSC will be assisting Native Plants, Inc. to fulfill a contract with the Department of Energy to study the extent of deep coal mine spoils in Utah and Colorado. We will be acquiring the photography and will perform interpretations to allow Native Plants a planning base for field studies of spoil characteristics.

PROJECT SUMMARY

Table 1 outlines the projects supported in whole or in part by NASA Grant NSG-7226 (and, since 1980, by NAGW-95) since its inception in August 1976. In all, 13 projects have been completed and 7 additional projects are underway. Some projects have had significant and direct management impact; others have proven effective with the expectation of management pay-off; and others have demonstrated their utility pending the availability of real-time or near real-time Landsat data delivery. It is noteworthy that funding, although limited, has been increasing from outside sources in state and federal agencies.

Most significant, however, is that NASA Grant NSG-7226 has in fact enabled CRSC to rise to state-of-the-art technology in remote sensing in five years of funding, with particular strength in digital processing. It is noteworthy that all of CRSC's project effort has been delivered directly into real-world, applied resource management issues, in direct service to agency on-going and rising needs.

CRSC's recent acquisition of ELAS, and installation of the PRIME computer, opens new horizons for CRSC in practical remote sensing and resource analysis work. Backing is still needed to bring us to a new level of expertise and operability in this area: through the implementation and perfection of GIS capabilities (fundamental to the new wave of state's expressed needs), digital terrain implementation, and multi-temporal techniques. All these are essential to bring digital remote sensing into full play in resource analysis. This is the expressed need of the State of Utah and federal and local agencies in a resource planning conscious, energy impacted, albeit underfunded, state.

Table 1. CRSC Projects Supported in Whole or Part by NASA Grants NSG-7226 and NAGW-95
(to July 31, 1981)

Project Short Title	CRSC Report	Agency/ies	Agency Support	Completed	Project Impact
PROJECTS COMPLETED					
North Ogden Hazards to Urban Development	78-1	Weber County, No. Ogden City, Pleasant View	Limited in Kind	May 1978	Adopted for Sensitive Area Overlay Zone Ordinance.
Irrigation Detection by Satellite, Iron Co.	79-1	Utah Div. of Water Rights	Limited in Kind	April 1978	Proven effective. Led to ground water study.
Price River Basin Rangeland Response to Summer Rain	79-2	U.S. Bureau of Land Management	Limited in Kind	May 1979	Proven effective but demands real-time data for application.
Korean Land Use II	79-3	Republic of Korea	$102,000	Aug. 1979	NASA funding helped develop software; technical development.
Snowpack/Runoff Correlation	Exper-imental	Utah Div. of Water Resources Soil Cons. Serv.	Limited	--	High correlations shown. Tabled until near real-time data is available.
Guayule Inventory I: Contrast Enhancement	80-1	Mexican Government	$90,000	Jan. 1980	NASA funding helped perfect computer enhancement.
Uinta Basin Wetland/Land Use	80-2	Utah Div. of Water Resources Soil Cons. Serv.	$10,000 $25,000	Dec. 1980	Wetland management, water allocation and management, agriculture resource planning.
Snow Cover/Mule Deer	80-3	Utah Div. of Wildlife Res.	Limited in Kind	July 1980	Landsat utility, tabled pending agency studies.
MX Draft EIS Review	81-1	Utah Governor's Office	ca. $2,000	April 1981	Used by Governor for MX policy and comment.
Guayule Inventory II: Statistical Classification Routines	81-2	Mexican Government	$100,000	Feb. 1981	NASA funding helped develop classification routines.
Farmington Bay Shoreline	81-3	Utah Div. of Wildlife Res. Great Salt Board	In Kind Minimal	April 1981	Deterred proposed project which would have damaged waterfowl habitat.
Irrigation Detection, Iron County II	81-4	Utah Div. of Water Rights	Minimal	May 1981	Proven effective; led to Beer River Study; leading to prosecution.
Davis County Foothill Development	81-5	Davis County Planning Comm. Four Corners Regional Comm. EPA 208 Weber-Davis Several State Agencies Seven municipalities	In Kind $63,000 $18,000 In Kind In Kind	May 1981	Being reviewed for adoption as the guideline for urban development control.

Table 1. (Continued)

CRSC Projects Supported in Whole or Part by NASA Grants NSG-7226 and NAGW-95

(to July 31, 1981)

Project Short Title	CRSC Report	Agency/ies	Agency Support	Anticipated Completion	Project Impact
PROJECTS UNDERWAY					
Sevier River Basin Wetland; Land Use	81-	Soil Conservation Service	$23,000	Nov. 1981	Basic information for wetland management and water allocation.
Wasatch-Cache Riparian Vegetation	81-	U.S. Forest Service	$3,500	Nov. 1981	Basic information for wetland;wildlife management.
Farmington Bay	81-	Utah Division Wildlife Resources	In Kind	Dec. 1981	Likely to influence diking, revegetation.
Bear River Range Aspen Habitat	81-	U.S. Forest Service, NSF	$13,000	Dec. 1981	Statistical signature refinement. Lead to riparian study.
Bear River Basin Irrigation Land Inventory	82-	Bear River Commission	$9,000	March 1982	Will be basis for water allocation between states.
Parker Mountain Rangeland	82-	Utah Division of State Lands	$4,541	April 1982	Basic information for revegetation, range Management.
Aspen/Aspen-Conifer Detection	82-	Intermountain Forest & Range Experiment Station	$7,499	May 1982	Improve inventory techniques and habitat analysis

Now that CRSC is firmly rooted in UURI, the Center needs to make an aggressive thrust into automated resource analysis applications, beyond the proven domain of digital remote sensing resource classification and inventory. Our studies are leading more than ever in this direction. We have the professional staff with resource analysis expertise (laboratory and field) and growing access to other resource specialists. The important issue at this juncture is to put this expertise to the test in applying automated GIS/digital terrain/multi-temporal analytical tools to work in the complex resource management/planning arena of Utah and a region consciously struggling with and adjusting to a combination of energy development, urban growth, water shortage, fragile environment, federally impacted problems.

CRSC's objective is to become fully prepared to enter substantially into this arena and to assert itself with demonstrable problem solving capabilities. Some continued funding is necessary to elevate us to that position.

EXHIBIT "A"

CRSC STUDY PLAN

RIPARIAN VEGETATION CLASSIFICATION OF THE WASATCH-CACHE NATIONAL FOREST

Primary Agency: Wasatch-Cache National Forest, U.S.D.A.

Utah Division of State Lands and Forestry
Utah Division of Wildlife Resources

Contact Persons: James Cole/Don Proctor
Wasatch Cache National Forest
125 East 1st South
Salt Lake City, Utah 84138
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David Schen
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Salt Lake City, Utah 84116
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Al Hagen/Bob Walters
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Salt Lake City, Utah 84116
Phone: 533-9333

Craig Pettigrew
Division State Lands and Forestry
160 N. Main
Logan, Utah 84321
Phone: 752-8701

Project Leader: John Merola, phone: 581-8017

Beginning date: May 21, 1981; Completion date: November 30, 1981

Objective: To map the riparian and wetland habitat of the Wasatch-Cache National Forest from Landsat digital data.

Purposes: 1. The National Forest Management Act (NFMA) requires that special management practices be implemented to maintain the integrity of riparian vegetation types because of associated timber, forage, recreation, water, wildlife values. NFMA and Regional Forester directives require that each national forest identify riparian areas and provide specific management plans for such areas. At the present time, the Wasatch-Cache National Forest does not possess sufficient information about its riparian habitats to serve as a management base for achieving compliance with said directives. This study will provide the Wasatch-Cache National Forest with its first comprehensive riparian habitat inventory, within its restricted time and budget constraints. Such inventory will provide the primary basis for the preparation of NFMA management plans for riparian zones. Riparian habitat information and management plans will directly affect other state and federal natural resource management agencies and local governments.

2. Both the Utah Divisions of State Lands and Forestry and Wildlife Resources have agreed to be coordinating state agencies in this project. The Division of State Lands and Forestry manages a sizeable tract of land within the Franklin Basin, as well as other state lands within or near national forest boundaries. This project will provide information about riparian habitat distribution which should assist state forest managers to better formulate their forest management plans. The non-game section of the Division of Wildlife Resources presently regards the nature and distribution of various types of wildlife habitat as a basic index of non-game wildlife distribution throughout the state. Numerous non-game animal species are either limited to forest riparian habitat or depend heavily on such areas for life-sustaining resources. Information about riparian habitat will assist Wildlife Resources Division personnel in their task of managing wildlife populations: a responsibility which extends to lands in federal, state, and private ownerhsip. Due to budget constraints, state participation in this project will be limited to some field assistance, review, and feedback.

3. It is anticipated that this study will enhance the technical capabilities of CRSC, by contributing toward the development of the ELAS software package recently acquired by CRSC. Available CRSC funds (through NASA) and any other available UURI funds, will be used to provide operational capability with the ELAS software system and UURI Prime computing facilities. Such technical capability would permit CRSC to provide automated line-map plotting, allow interfacing of digital terrain data with Landsat information, and enable overlaying digitized Forest Service land ownership information with riparian resource maps.

Study Area: Forest and range areas in and adjacent to the Wasatch-Cache National Forest, excluding the Vernon Division.

Study Approach:

1. Materials

   a. Landsat Imagery. Landsat computer compatible tapes (CCT) and false color composite images will be required for the following scenes:

CRSC Scene Reference	Date	Path	Row	EROS I.D. Number
South Great Salt Lake	7/2/79	41	32	30484-17303
North Great Salt Lake	7/2/79	41	31	30484-17300
Southern Uinta Mountains	9/11/79	40	31	30555-17242
Northern Uinta Mountains	9/11/79	40	30	30555-17233

   CCT's for the South Great Salt Lake and Southern Uinta Mountain scenes are already available to CRSC; reformatted Landsat data is available for the North Great Salt Lake scene. Landsat photo-images are available for the two Great Salt Lake scenes. Photo-images will be ordered for the Uinta Mountains scenes, and a CCT will be ordered for the Northern Uinta Mountains scene.

   b. Aerial Photography. Existing high-altitude color infrared photography (U-2) for August 1 and 2, 1979 (ca. 1:30,000 scale) will be utilized for those portions of the study area covered by the flight lines. Such photography is owned by CRSC and limited to Wasatch Front portion of the study area.

   The Wasatch-Cache National Forest (WCNF) will permit CRSC to use a set of its low altitude natural color and available color infrared photography coverage for the entire study area throughout the study. The WCNF will also provide CRSC with a flight line key for such photos.

   c. U.S.G.S. Maps. The WCNF will provide CRSC with a full set of 7.5 minute orthophoto quadrangles and a full set of topographic quadrangles for its use in this project, which maps will be retained by CRSC upon project completion.

2. Equipment

   No new equipment is anticipated for this project.

3. Analysis

   Computer compatible tapes of the four Landsat scenes covering the study area will be digitally processed to map the land cover classes based on Landsat. Available aerial photos will be utilized to provide initial verification and augment the analysis of riparian habitat classifications. Areas improperly classified through digital processing routines will be reclassified to conform to aerial photo and/or field observations.

At least one trip will be arranged between the project participants to allow the CRSC project leader to accompany WCNF personnel, in a Forest Service vehicle, to various locations within the study area for the purpose of verifying portions of the digitally-produced maps. Upon completion of as much field verification by CRSC personnel as possible, a final print map of riparian habitats will be produced.

The level of detail in the classification of riparian plant communities which is necessarily limited by the time and budget constraints of this study, will be guided by the following list of first and second priority classifications:

First Priority	Second Priority
Coniferous Riparian	Spruce/Fir Riparian Lodgepole Riparian
Deciduous Tree Riparian	Aspen Riparian Cottonwood Riparian
Shrub Riparian	Tall Willow Riparian Low Willow Riparian
Meadow	Sedge Hairgrass
Water	Streams* Lakes

*where adjacent riparian communities are identifed, streams need not be mapped as a riparian unit.

Riparian type includes aquatic ecosystem components of water and water-dependent vegetation. The type includes streamsides, potholes, valley bottoms, wetlands, floodplains, wet meadows, stream channels and lakes. For the purposes of this study 100 feet from the edge (high water line) of perennial streams or other water bodies is considered riparian zone. The final print maps of riparian habitats will be georeferenced to the 7.5 minute quadrangles and transferred to sepia mylar to produce translucent overlays. Selected overlays will be sent to Forest Service personnel located at various district offices to verify the mapping pre-selected areas. Such verification will be accomplished by reference to readily available knowledge of various portions of the study area. Such Forest Service personnel will report their responses to the WCNF contact person, who will then summarize and review such feedback with CRSC. Upon receipt of such limited map verification by CRSC, a final report will be prepared along with a full set of translucent overlays.

4. Final Products

CRSC will produce the following:

a. One set of transclucent overlays of digital print maps and keys registered to the quadrangles covering the study area.

b. An analytical report with a description of CRSC's research techniques and discussion of study findings and mapping limitations.

c. A copy of a computer tape of the digital riparian habitat classification, in a format to be specified by the WCNF.

Tentative Completion Schedule:

Stage No.	Description	Target Date
1	Order CCT + photo-images for Wasatch-Cache N.F.	5/21/81
2	Acquire available aerial photography from WCNF as well as U.S.G.S. ortho-photo and topographic contour quads	6/05/81
3	Reformat CCT (subject to time of arrival from EROS)	7/06/81
4	Identify training areas for creating statistics	7/10/81
5	Create statistics file, produce initial print map	7/17/81
6	Ground-checking windows (aerail photointerpretation and field trip(s)	8/07/81
7	Final classification of entire study area	8/14/81
8	Constants program (control points), and Georef	8/19/81
9	Drafting registration borders for maps, and labels	8/21/81
10	Verification of final print maps by WCNF	9/25/81
11	Completion of final products	10/31/81

PROJECT BUDGET: Riparian Vegetation Classification of the Wasatch-Cache National Forest

	FUNDING SOURCES		
	WCNF	NASA	TOTAL
Personnel			
Salaries	$ 602	$ 3378	$ 3980
Hourly		300	300
Employee Benefits			
Salary: .416 x	250	1406	1656
Hourly: .07 x		21	21
Total Personnel	$ 852	$ 5105	$ 5957
Travel		400	400
Supplies (sepia mylar, photography, film organization)	300	600	900
Consultants (Director)		750	750
Communications/Publications		400	400
Data Processing	1000	2000	3000
Sub-Total Direct Costs	$ 2152	$ 9255	$11,407
Indirect Costs			
General & Administration	258	1111	1369
Overhead	861	3702	4563
Sub-Total Indirect Costs	$ 1119	$ 4813	$ 5932
Management Allowance	229	-0-	
Total Budget: WCNF	$ 3500		
Total Budget: NASA		$14,068	
TOTAL BUDGET			$17,568

EXHIBIT "B"

IRRIGATED ACREAGE IN THE BEAR RIVER BASIN

BY STATE AND COUNTY:

AS OF THE 1975 GROWING SEASON

June 10, 1981

A

PROPOSAL

TO THE

BEAR RIVER COMPACT COMMISSION

FROM THE

CENTER FOR REMOTE SENSING AND CARTOGRAPHY
UNIVERSITY OF UTAH RESEARCH INSTITUTE
420 Chipeta Way, Suite 190
Salt Lake City, Utah 84108
UURI — A Non-Profit Organization

CONTACTS

TECHNICAL

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(801) 581-8016

BUSINESS

C.A. Jones
(801) 581-5066

Approved:

Merrill K. Ridd, Director CRSC
Principal Investigator

Wayne O. Ursenbach, Vice-President
University of Utah Research Institute

INTRODUCTION

The Bear River Compact established by U.S. Senate Bill S-1489, decreed that water originating in the Bear River Basin (Figure 1) be allocated among the three participating states according to the relative amount of land under active irrigation as of January 1, 1976. It follows that the 1975 growing season would be the appropriate period to determine active irrigated acreage, being the period of use immediately preceding the effective date of the compact.

It also follows that remotely sensed data provides the only objective data source from which irrigated acreage can be determined for a past point in time. Basically, there are three reasonable approaches to such determination through remote sensing: visual interpretation of aerial photography (black and white, natural color, or preferably color infrared); visual interpretation of satellite imagery; or digital interpretation of satellite data. To objectively utilize photography would require uniform coverage over the entire basin for the target date or season. While there is some black and white photography and some color infrared photography over parts of the basin for 1975, large areas remain without coverage for that season. Another problem encountered with an inventory based entirely on aerial photography is that such photography, where available, only provides a single date for the estimation of irrigated acreages. It remains for the Landsat satellite to provide the only uniform data available over the entire basin for the specified season. During the 1975 season, both Landsats 1 and 2 were in operation, on approximately a 9-day return interval.

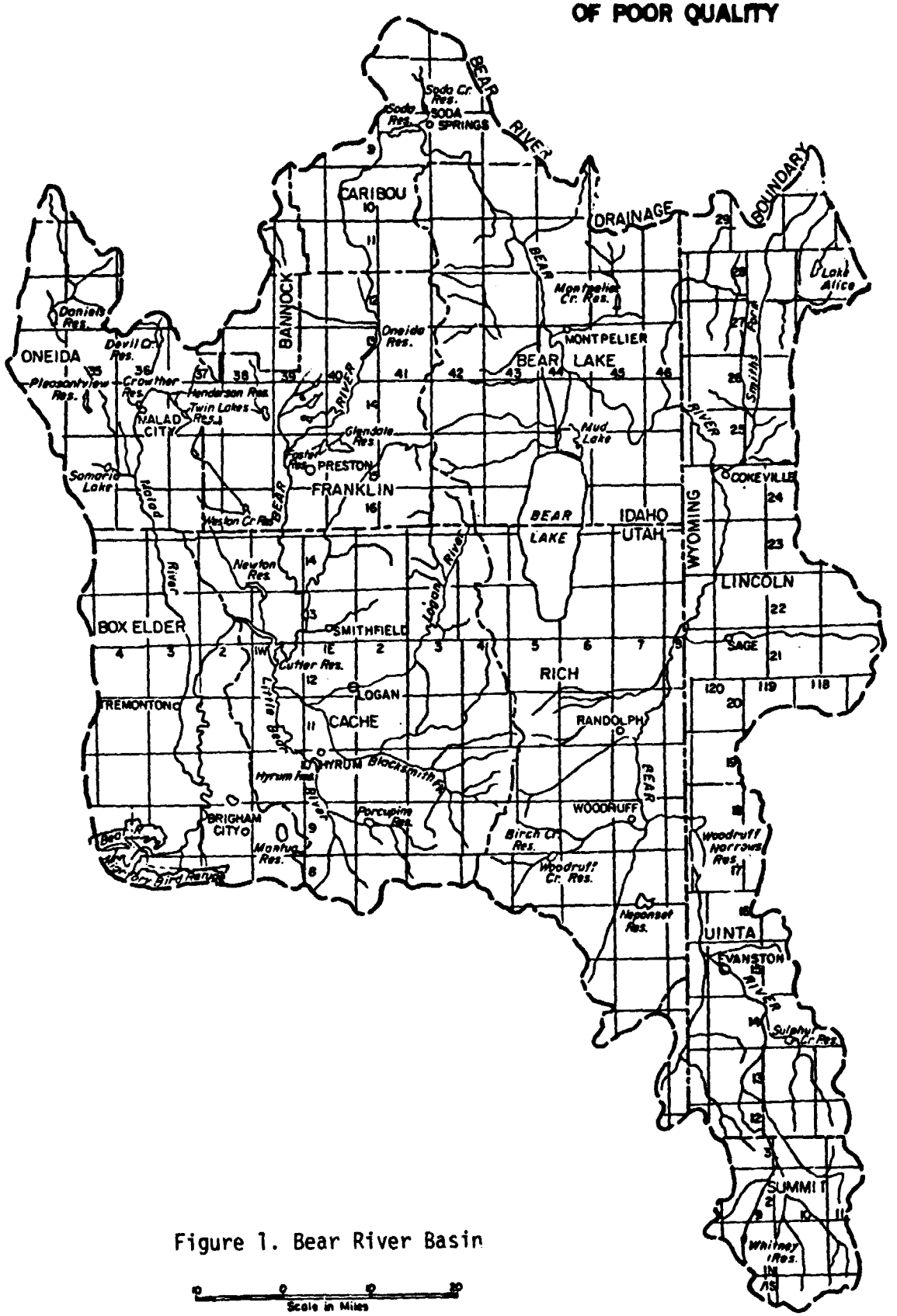

Figure 1. Bear River Basin

Scale in Miles

PURPOSE

The purpose of the proposed study is to provide consistent and objective determination of irrigated land acreage during the 1975 growing season for the entire Bear River Basin. Acreage will be subtotaled by county within each state. The specification of "consistent and objective" acreage determination cannot be over-emphasized. It is self evident from the basic premises of the compact that unbiased acreage measurements must be obtained across all three states in the Basin. Experience shows that uniformity of results can only obtain if the same set of eyes and hands perform the entire inventory under the same supervisory guidelines and verification criteria.

METHODOLOGY

The most proven technique for this purpose would be the conjoint use of colorinfrared (CIR) photography with Landsat digital data (see Ridd, et al., 1981a). In the absence of CIR photography for the entire basin, and given a limited budget the most effective and consistent technique is the visual interpretation of Landsat false color composite (FCC) imagery. CRSC has demonstrated the utility of this technique in a study of irrigated land in southern Utah (Ridd and Harmon, 1979). In this and a subsequent study (Ridd, et al.,1981b) it was also shown that a single date is inadequate to determine active irrigated acreage for the season, especially for crops with intraseasonal cycles of production, such as alfalfa. At least two, and preferably three dates should be carefully selected through the growing season.

As in earlier studies, the FCC imagery will be selected (clouds, quality, and coverage permitting) representing the most appropriate distribution through one season: ideally the first of June, July, and August. The imagery will be

enlarged to 1:125,000 scale through special order to EROS Data Center, the national outlet for NASA data. For each enlarged FCC a township and section grid will be accurately perpared and carefully placed as an overlay over each of the images for three dates in each agricultural area.

Two trained analysts will independently interpret each field (or group of fields) in the basin and make two decisions: (a) whether it is irrigated (as of that date), and (b) if so, how many acres. The data will be independently tabulated, and then compared. A third analyst will independently check all fields in disagreement on decision (a) and all fields with greater than $\pm$ 5% variation on decision (b). For all other fields a mean acreage value will be derived between the two estimates. For the fields with $>\pm$ 5% variation, the third analyst will either make a determination or confer with the other two analysts and make a decision.

As each agricultural area or valley is completed a field verification procedure will be employed. A random sample of 2% of all 160 acre grid cells will be checked in the field. The principal objective of the field verification is to determine whether the (a) question was answered correctly. Verification will proceed by first determining whether a water diversion device connects with the field in question. It will be necessary to assume that where such a diversion device connects to a given field which appears to be well vegetated on the Landsat imagery, that such field was irrigated during the 1975 growing season. Some of the field verification may be possible from maps in the respective state water offices and/or through contact with the owner by mail or telephone.

Of particular concern is the possible confusion between manually irrigated land and naturally flooded or subirrigated bottom land. An operational definition will need to be worked out to distinguish such naturally occurring wetland or pasture from human irrigation. This distinction will be the most difficult part of the study because of the abundance of floodplain terrain and vegetation in the study area.

WORKING COPY

The Bear River Basin, covering some 7,244 square miles (Haws and Hughes, 1973) falls largely within one Landsat scene. However, the northern portion typically falls in an adjacent scene. Furthermore, the satellite sometimes "strays" a little to the east or west, requiring a portion of still another scene. As the FCC special enlargements are prepared not more than one-quarter of the scene can be enlarged at once. Thus 6, or perhaps 7, enlarged quadrants will be required for each date – a total of 18 to 21 special enlargements, each 36 by 36 inches. These will be the working copy base for all interpretations in the laboratory and field. The township and section overlay will be moved from date to date on each quadrant.

PRODUCTS

The end products of the study will be:

1. A report detailing the methodology, the procedural issues and decisions, and the findings, including a tabulation of the actively irrigated acreage, as of the 1975 growing season, by county and state, and by sub-units within the Bear River Basin: five (5) copies for the Compact Commission and three (3) copies for each of the three states. The report will include appropriate location maps and illustrative photographs.
2. A false color composite index mosaic of the Bear River Basin as a whole at 1:250,000 scale (about 36 inches square), showing the basin divide, state and county boundaries, significant cities or landmarks, and sub-unit division as indicated in Figure 2.

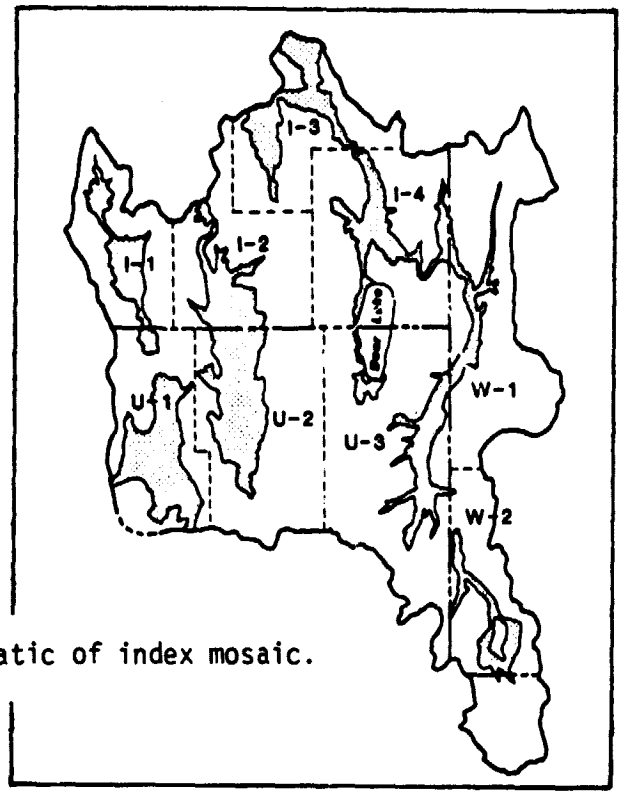

Figure 2. Schematic of index mosaic.

3. A three-date display of each sub-unit within each state at 1:125,000 scale with township and section overlays, as suggested in Figure 3.

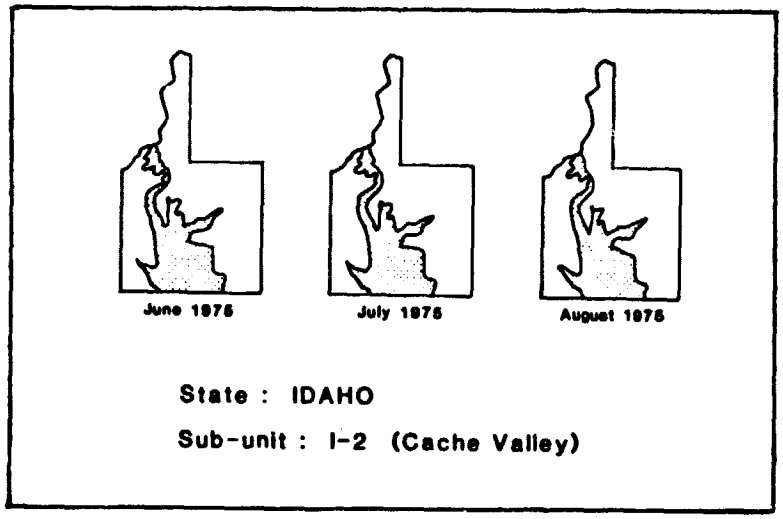

Figure 3. Schematic of a sub-unit display.

Additional copies of all products may be obtained upon request at cost.

SCHEDULE

Assuming contract approval by June 20, 1981, and assuming appropriate imagery can be obtained for the dates desired and with the special enlargement by four weeks after the contract approval, laboratory and field work will be completed by November 30, 1981, and final products submitted by December 15, 1981.

CRSC EXPERIENCE

The Center for Remote Sensing and Cartography (CRSC) is a well established research facility with six years' experience in performing laboratory and field based work in applied remote sensing in the Intermountain Region and abroad. The enclosed brochure and literature highlight some of the project work completed. The Center also has some base-level funding from the National Aeronautics and Space Administration (NASA) for the purpose of working on applied projects in the region.

The Center is a part of the University of Utah Research Institute, whose mission is to work on practical problems, as distinct from basic or academic tasks. As an applied research entity the Institute is committed to completing project work on time, as specified, and within budget. Further, as the name implies, every project employs the latest and most appropriate techniques available, with an eye to innovation of improved techniques, appropriate to the task, for each job.

As a non-government entity, CRSC can remain totally detatched as an objective facility in service to all three states with total and impartial interest to all.

The personnel at CRSC are all professionally trained in this area to

work on problems within this area, and all have a personal commitment to perform professional service at the state-of-the-art for the benefit of the agencies and people in the area. Aggregate training and experience by the staff includes nine degrees, and credentials encompassing geography, watershed science, plant ecology, law, and environmental planning. The Center has full capabilities in manual (visual) and digital classification and mapping in remote sensing, aircraft and satellite data analysis, and a strong field skill orientation. We invite the Compact Commission and affiliated people to visit our facilities and to examine reports and products if they so desire.

REFERENCES

Haws, F.W., and T.C. Hughes. 1973. Hydrologic Inventory of the Bear River Study Unit. Division of Water Resources and Utah Water Research Laboratory. 126 p.

Ridd, M.K., J.G. Christensen, L.D. Clark, Jr., and K.F. Landgraf. 1981a. Uinta Basin Wetland/Land Use Study: A Merger of Digital Landsat and Aircraft CIR Techniques. Center for Remote Sensing and Cartography Report 80-2. 27 p. and Appendices.

Ridd, M.K., and L.M. Harmon. 1979. Irrigation Detection by Satellite, Iron County, Utah, 1978. Center for Remote Sensing and Cartography Report 79-1. 3 p. and Appendices.

Ridd, M.K., K.F. Landgraf, and L.D. Clark, Jr. 1981b. Irrigation Detection by Satellite, Iron County, Utah, 1978, 1979, and 1980. Center for Remote Sensing and Cartography Report 81-4. 8 p. and Appendices.

PROJECT BUDGET: Irrigated Acreage in the Bear River Basin, 1975

	FUNDING SOURCES		
1. Direct Costs	Bear Riv. Compact C.	CRSC/NASA Grant	TOTAL
Personnel			
Salaries	$ 720	$ 720	$ 1440
Hourly	1386	1386	2772
Employee Benefits			
Salary: 41.6%	299	300	599
Hourly: 7.0%	97	97	194
Total Personnel	$ 2502	$ 2503	$ 5005
Travel	600	600	1200
Supplies (photography, drafting materials, postage)	150	150	300
Consultants (Director)	1387	1588	2975
Communications/Publications	150	150	300
Sub-Total Direct Costs	$ 4789	$ 4991	$ 9780
2. Indirect Costs			
General and Administration	575	599	1174
Overhead	1916	1996	3912
Sub-Total Indirect Costs	2491	2595	5086
3. Management Allowance	510	0	510
Total Budget: Bear River Compact Commission	$ 7790		
Total Budget: CRSC/NASA		$ 7586	
COMBINED BUDGET			$ 15376
Purchase of Landsat imagery by the Bear River Compact Commission:	$ 2200		

Explanation of Major Budget Items

1. Direct Costs.

The budget has been prepared to reflect the costs of 3½, 3, and 12 man-weeks of effort by CRSC's director, manager, and technicians, respectively. Of the total work effort, 4 man-weeks will be spent in the field for map verification purposes; two field trips and associated travel and per diem expenses are anticipated with durations of one-half and one weeks. Other direct costs are closely associated with the gathering of necessary data and production of graphic materials.

2. Indirect Costs.

The indirect costs shown are assessed as a standard percent charge against the direct costs. A 12% charge is assessed for UURI general and administrative overhead. The overhead allowance for CRSC's use of the UURI facilities and administrative costs of CRSC and the Applied Technology Division of UURI has been approved by federal auditors at 40% of direct costs.

3. Management Allowance.

The description of this cost component applies to cost reimbursement contracts, which is the type of contract contemplated in the proposal. The current rate is 7%, assessed against the total of direct and indirect costs, unless advance payment or Letter of Credit financing is provided, where the rate becomes 5%. Some examples of expenses covered by this allowance are: interest, contingent salaries, precontract cost, in-house research, costs per audit and/or negotiation, working capital (to adjust for delays in receiving invoice payments), and initial capital equipment purchases.

The University of Utah Research Institute is totally self-supporting and receives no financial support from either the University of Utah or the State of Utah, and hence, includes a Management Fee as the only source of funds for the above-stated purposes.

EXHIBIT "C"

SHORT TITLE: Aspen Succession

CRSC STUDY PLAN

TECHNIQUE DEVELOPMENT AND TESTING FOR CLASSIFYING AND INVENTORYING ASPEN AND ASPEN-CONIFER STANDS

PRIMARY AGENCY: U.S.D.A. Intermountain Forest and Range Experiment Station

COOPERATING AGENCIES: Wasatch-Cache National Forest
Utah Division of State Lands and Forestry

CONTACT PERSONS: Roy Harniss
Forestry Sciences Laboratory
860 N. 1200 East
Logan, Utah 84321
801-752-1311

James Cole
Wasatch-Cache National Forest
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Salt Lake City, Utah 84138
801-524-5107

David Schen
Utah Division of State Lands and Forestry
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Salt Lake City, Utah 84116
801-533-5430

Craig Pettigrew
Utah Division of State Lands and Forestry
160 N. Main
Logan, Utah 84321
801-752-8701

PROJECT LEADER: Richard Jaynes; phone: 581-8016

BEGINNING DATE: July 15, 1951 COMPLETION DATE: June 1, 1982

OBJECTIVES:

1. Utilize Landsat digital data to devise quantitative indices which correlate with apparently stable and seral aspen forests.

2. Map and determine areal coverage of several classes of stable/seral aspen forests in the Bear River Range, Utah.

3. Delineate, to the extent possible from Landsat digital data, six categories of aspen and aspen/conifer mix: aspen with aspen reproduction; aspen with herbaceous understory; aspen with shrub-dominated understory; early seral aspen; mid seral aspen; late seral aspen.

PURPOSES:

1. The Intermountain Forest and Range Experiment Station is interested in developing research techniques which combine the use of remote sensing technology and ground truth data to study and map the extent of stable and seral aspen forests in the Intermountain area. The understory attributes of aspen forests and successional phases, produced by conifer invasion of aspen, are expected to produce distinctive spectral responses; the ability to detect such variations in aspen forests will be a valuable tool for inventorying aspen and associated range, wildlife and watershed attributes.

2. Forest managers need to have a means to assess the extent to which aspen stands are being converted to coniferous forests. The application of Landsat digital processing methods suggests a relatively quick and inexpensive means to address the problems associated with the succession process on a forest, ranger district, or planning unit basis.

STUDY AREA:

Stable and seral aspen classes will be mapped for the portions of 15 1:24,000 U.S.G.S. quadrangles in the Bear River Range of Utah and Idaho, as indicated below:

Idaho	Utah
Mink Creek (S ½)	Naomi Peak (All)
Paris Peak (S ½)	Tony Grove (All)
Paris (S ½)	Garden City (All)
Mapleton (All)	Mt. Elmer (All)
Egan Basin (All)	Temple Peak (All)
St. Charles (All)	Meadowville (All)
	Logan Peak (All)
	Boulder Mountain (All)
	Red Spur Mountain (All)

Approximate area: 485,000 acres.

FINAL PRODUCTS:

1. An acetate digital print map overlay for each U.S.G.S. 1:24,000 quadrangle.

2. A technical report describing methods and results (including quad by quad acreage calculations of aspen classes)

MATERIALS NEEDED:

1. Landsat tapes and imagery:

RESPONS.	DATE	SCALE	PATH	ROW	EROS I.D. NO.
CRSC	7/2/79	1:250,000	41	31	30484-17300

2. Conventional photography:

Low altitude natural color aerial photography on loan from the Wasatch-Cache N.F. will be available. The Intermountain Station will make available, on a loan basis, any of its aerial photography found useful for the study.

EQUIPMENT AND OTHER NEEDS: Full sets of 1:24,000 standard U.S.G.S. quads and orthophoto quads for the study area.

STUDY APPROACH:

Analysis

Data on computer compatible tapes of the Landsat scene covering the study area will be digitally processed to map classes of aspen and aspen-conifer stands. Available aerial photos and input from Intermountain Station personnel will be used to select windows which will be examined by the SEARCH program to generate spectral signatures. Statistical analyses will be performed to complete the initial statistics file for signatures.

The pixels in the study area will then be correlated through the application of a maximum likelihood routine (CLASSIFY) with spectral signatures. The print map produced by CLASSIFY will be evaluated in the lab to determine acceptability of print character assignments and general spatial patterns. If necessary, additional windows will be "searched" and/or signatures added to improve the initial classification.

After an initial classification is developed, ground control points will be identified, and the geo-referencing program CONSTANTS will be run. Then, 1:24,000 scale print maps will be produced with the program GEO-REF. Such maps will then be calibrated to ground truth by selecting field plots located within homogeneous areas within each of the pixel classes. Intermountain Station personnel will provide the bulk of the ground truth data for analyzing the accuracy of the classification. If the initial classification is unacceptable, then adjustments to the signatures and/or signature statistics files will be made. A refined print map will then be produced and again be calibrated to available ground truth.

After a final print map classification is produced, an additional ground truth investigation will be conducted to verify the predictive ability classification. Personnel from the Intermountain Station will provide the verification ground truth data.

Final map products will be produced and a technical report which contains a

summary of project methodology, quad acreage tabulations by class, and an analysis of the calibration and verification results will be prepared.

Tentative Completion Schedule:

Stage No.*	Description	Target Date
1	Obtain information regarding available aerial photography from the Intermountain Station; obtain U.S.G.S. standard quads and orthophoto quads.	8/03/81
2*	Identify windows for creating signature statistics	8/05/81
3	Create statistics file and produce signature plot	8/07/81
4*	Produce initial classification and perform laboratory evaluation	8/12/81
5	Complete initial classifications	8/14/81
6	Ground control points and CONSTANTS	8/14/81
7	Geo-referenced 1:24,000 maps	8/19/81
8*	Calibration of initial classification with ground truth	9/15/81
9*	Complete calibration of classification	11/18/81
10	Drafting registration borders for maps and labels	1/16/82
11*	Verification of final print maps	3/05/82
12	Completion of final products	5/01/82

*Stage numbers shown with an asterisk indicate steps where input from the Intermountain Station is critical to the progress of the project.

PROJECT BUDGET: Technique Development and Testing for Classifying and Inventorying Aspen and Aspen-Conifer Stands

	FUNDING SOURCES		
	INT	CRSC/NASA	TOTAL
1. DIRECT COSTS			
Personnel			
Salaries	$ 2,500	$ 700	$ 3,200
Benefits	1,040	291	1,331
Total Personnel	3,540	991	4,531
Non-Personnel			
Travel	$ 171	$ 579	$ 750
Supplies (mylar, photography)	150	150	300
Consultants (Director)	150	250	400
Communications/Publications	100	-0-	100
Data Processing	500	200	700
Total Non-Personnel	$ 1,071	$ 1,179	$ 2,250
TOTAL DIRECT COSTS	$ 4,611	$ 2,170	$ 6,781
2. INDIRECT COSTS			
General and Administrative	$ 553	$ 260	$ 813
Overhead	1,844	868	2,712
TOTAL INDIRECT COSTS	$ 2,397	$ 1,128	$ 3,525
TOTAL DIRECT & INDIRECT COSTS	$ 7,008	$ 3,298	$10,306
3. MANAGEMENT ALLOWANCE	$ 491	$ -0-	$ 491
Total Budget: INT	$ 7,499		
Total Budget: CRSC/NASA		$ 3,298	
COMBINED TOTAL BUDGET			$10,797

EXHIBIT "D"

RANGE RESOURCES INVENTORY:

PARKER MOUNTAIN, UTAH

September 15, 1981

A

PROPOSED STUDY PLAN

TO THE

UTAH DIVISION OF STATE LANDS AND FORESTRY

FROM THE

CENTER FOR REMOTE SENSING AND CARTOGRAPHY

UNIVERSITY OF UTAH RESEARCH INSTITUTE

420 Chipeta Way, Suite 190

Salt Lake City, Utah 84108

UURI - A Non-Profit Organization

CONTACTS

TECHNICAL

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BUSINESS

C. A. Jones (801) 581-5066

Approved:

Richard A. Jaynes, Manager, CRSC
Principal Investigator

Wayne O. Ursenbach, Vice President
University of Utah Research Institu

CRSC STUDY PLAN

RANGE RESOURCES INVENTORY: PARKER MOUNTAIN, UTAH

PRIMARY AGENCY: Utah Division of State Lands and Forestry

COORDINATING AGENCY: Soil Conservation Service

CONTACT PERSONS:

Louis Brown
Utah Division of State Lands and Forestry
146 North Main
Richfield, Utah 84701
801-896-5761

William Dinehart
Utah Division of State Lands and Forestry
231 East 400 South
Salt Lake City, Utah 84111
801-533-5381

Walter Blake
Soil Conservation Service
55 South 100 East
Richfield, Utah 84701
801-896-4545

PROJECT LEADER:

Richard Jaynes
801-581-8016

BEGINNING DATE: September 9, 1981 COMPLETION DATE: April 22, 1982

OBJECTIVES:

1. Prepare a map of rangeland vegetation types on Parker Mountain, Utah, utilizing color infrared photography.

2. Correlate, to the extent feasible under the project budget, map units and field checking with forage production data previously collected by the Soil Conservation Service, and provide management recommendations.

PURPOSES:

1. Provide a basic spatially-oriented range management information base by focusing on terrain and vegetation characteristics for the purpose of developing grazing management plans for lessees of state lands.

2. Provide basic input to land use planning on Parker Mountain so that range improvements will be located in areas where they are needed most and to avoid conflict with future recreation development on state lands.

3. The Parker Mountain Study Area is a large block of state rangeland; resource information is needed for its effective management. The technique used in this

PURPOSES: (Cont'd) study could be applied to any state land in Utah since fairly recent high altitude color infrared aerial photography is available for most state lands. Thus, the study will provide an evaluation of the cost-effectiveness and efficiency of inventorying resources in the manner proposed. Also, since current landsat imagery is available for all areas in the state, the feasibility of utilizing such imagery to map vegetation resources will be explored.

STUDY AREA: The contiguous block of state-owned land on and around Parker Mountain, near Richfield, Utah. The following four U.S.G.S. 7½ minute quadrangles cover the study area:

Jake's Knoll
Parker Knoll
Flossie Knoll
Angle

FINAL PRODUCTS:

1. Mylar overlay to the mosaiced four-quad study area base showing delineations of different rangeland cover types and allotment boundaries (scale 1:24,000).
2. Technical report describing methods, results, and management recommendations.
3. Landsat digital print map overlay of the study area (clear sepia).
4. Table showing the acreage of vegetation types within each grazing allotment.

MATERIALS NEEDED:

1. Landsat Tapes and Imagery:

Date	Scale	Path	Row	EROS I.D. No.
7-28-79	1:250,000	40	33	821648-17191

2. High Altitude Photography:

BLM-MRIR aerial mapping CIR photography; July, 1975; scale: 1:31,680.

NASA-high altitude CIR photography (1:65,000) flown June-July 1981 (if available for the study area).

3. Conventional Photography:

CRSC Ortho photography (1:24,000) from the Western Aerial Photography Field Office (ASCS), flown in 1978.

EQUIPMENT AND OTHER NEEDS:	Access to Kargl cartographic projector, electronic acreage estimating program. Four U.S.G.S. topographic quads and four ortho-photo quads. Loan of fenceline overlay from the Division of State Lands.
ANALYSIS:	This study may be divided into two aspects: The primary effort will focus on preparing a hand-drawn overlay of rangeland vegetation types from available aerial photography. The second task will be to utilize the information obtained in the primary mapping effort to assess the accuracy of a Landsat digital analysis of vegetation and terrain features. The Landsat medium for the inventory of resources will proceed jointly with the aerial photo interpretations, and is expected to be of assistance in completing the primary mapping task. CRSC plans to map vegetation into the following primary units: aspen, conifer, big sage, black sage, and grassland. Secondary delineations (e.g., based on steep slopes) will be made within such types if the photographic medium permits. The map that is contemplated will provide a base for further vegetation or range condition subdivisions based upon field observations. Since Landsat digital data are already available to CRSC, they will be used to augment the mapping project where possible. The costs of experimental use of Landsat data will be borne by CRSC under its NASA grant. It will be necessary for field personnel from the Division's office in Richfield to cooperate with CRSC in field checking the maps. Also, CRSC will need to borrow the Division's map showing fencelines and other range improvements.

Tentative Completion Schedule:

Stage	Description	Target Date
1	Preliminary delineations of range cover types from aerial photos in the lab.	7-23-81
2*	Initial field trip to check delineations	7-29-81
3*	Development of preliminary map legend and acquisition of S.C.S. field production data, etc.	9-18-81
4	Create Landsat statistics file from training areas, produce initial print map	9-25-81
5	Ground control points, CONSTANTS & GEOREF	9-28-81
6	Produce print map overlay to study area	9-30-81
7*	Field trip to collect transect data and calibrate Landsat classes	10-6-81
8	Final Landsat classification of the study area	10-15-81
9*	Final legend development and map corrections	10-20-81
10	Final drafting in ink on mylar	11-20-81
11	Final reproduction of overlays and print maps and acreage determinations	1-22-82
12	Technical report and visual abstract completion	3-17-82
13	Delivery of final graphics and report	4-22-82

* Stage numbers shown with * indicate steps where input from the Division of State Lands and Forestry is critical to the progress of the project.

PROJECT BUDGET: Range Resources Inventory: Parker Mountain, Utah

	Div.St.Lands	CRSC/ NASA	Total
1. DIRECT COSTS			
Personnel			
Salaries	$ 440	$1,100	$1,540
Hourly	1,300	250	1,550
Employee Benefits			
Salary: 41.6%	183	458	641
Hourly: 7.0%	91	35	126
Total Personnel	2,014	1,843	3,857
Non-Personnel			
Travel	530	100	630
Supplies (film, photography, imagery, drafting)	180	250	430
Consultants (Director)	0	300	300
Communications/Publications	50	50	100
Data Processing	0	500	500
Total Non-Personnel	760	1,200	1,960
TOTAL DIRECT COSTS	2,774	3,043	5,817
2. INDIRECT COSTS			
General & Administrative Overhead	333	365	698
CRSC/ATD Overhead	1,137	1,248	2,385
TOTAL INDIRECT COSTS	1,470	1,613	3,083
TOTAL DIRECT & INDIRECT COSTS	4,244	4,656	8,900
3. MANAGEMENT ALLOWANCE	297		297
Total Budget: Div. of St. Lands	$4,541		
Total Budget: CRSC		$4,656	
COMBINED TOTAL BUDGET			$9,197

EXHIBIT "E"

state of utah

DIVISION OF WILDLIFE RESOURCES

DOUGLAS F. DAY
Director

1596 West North Temple/Salt Lake City, Utah 84116/801 533-9333

August 7, 1981

Mr. Richard A. Jaynes
University of Utah Research Institute
Center for Remote Sensing
420 Chipeta Way, Suite 190
Salt Lake City, Utah 84108

Dear Richard:

Thank you, belatedly, for sending the abstract of "Satellite Mapping of Shoreline Fluctuations, Farmington Bay, Great Salt Lake, Utah". I have projected the material and have already found that I can use it effectively to help me with some discussions I have coming up.

All of you have been great to work with and I hope we can find some way to continue in the future. I do appreciate all you have done.

Sincerely,

Albert F. Regenthal
Wildlife Program Coordinator

AFR:sa